all year and had a consistent flow that ranged from 40-60 gpm. Nitrate concentrations at S8 were above 10 mg/l in each of the quarterly samples.

Potter Creek is another spring-fed stream, and one of the larger of the many springs, S9, was sampled. This spring emerged from the remains of an old spring house and had a variable flow that ranged from 20 gpm in October to more than 200 gpm in April. The water chemistry at this site was characterized by naturally high alkalinity and high total hardness. The nitrate concentrations at this spring were greater than 10 mg/l during each of the four sampling events.

The final spring that was sampled, S10, flowed into Three Springs Run from a depression in a private lawn. The sample was taken as the water was coming out of the ground, which is evidenced by the low dissolved oxygen values and the constant temperature between 10-12 °C throughout the year. The discharge at this spring was fairly constant at approximately 100 gpm. Nitrate concentrations at this spring were approaching, but did not exceed, the 10 mg/l drinking water standard.

All springs were ranked by their average concentrations of nitrate throughout the sampling period (Figure 6). Five of the 10 springs had average nitrate concentrations that exceeded the 10 mg/l drinking water standard. These springs were the Cabbage Creek spring (S1), Plum Creek Spring 1 (S3), Plum Creek Spring 2 (S4), Yellow Creek Spring 2 (S8), and Potter Creek Spring (S9). Additionally, S10 on Three Springs Run was approaching the MCL at 9.12 mg/l.

Water Typing

In addition to an assessment of the general water quality, biological conditions, and habitat in Morrison Cove, the water chemistry data were used to group streams together that had similar characteristics. This process is generally referred to as water typing and consists of characterizing the geochemical composition of water. Water typing is possible because the constituents of water are directly related to the geologic formation of origin; thus, it is possible to determine the source of water for streams and springs. Most streams in any area are of the same general type and are influenced by the same factors. For example, water from a limestone geologic area is usually characterized by higher calcium concentrations due to the calcium bicarbonate dissolved into the water.

However, water containing a higher concentration of magnesium may indicate a dolomite source. There are distinct geologic units within the Morrison Cove region that have known chemical properties, and the source of the water can be determined based on these chemical signatures (i.e. Ca^{+2}/Mg^{+2}). The main geologic units in Morrison Cove are limestone, dolomite, mixed limestone/dolomite, and sandstone. Despite the ridge and valley geology in Morrison Cove and the distinct geologic formations, there were minimal differences in the parameters that distinguish one type of water from another. However, some general conclusions about the origin of the water at certain locations in Morrison Cove can be drawn.

In theory, water that originates from pure dolomite has a Ca^{+2}/Mg^{+2} ratio of 1.0 while water that originates from pure limestone will have little or no magnesium and a Ca^{+2}/Mg^{+2} ratio approaching six (Lindsey and Koch 2004). However, for practical purposes, water with a Ca^{+2}/Mg^{+2} ratio less than 1.5 can be considered dolomite based, while water with a Ca^{+2}/Mg^{+2} ratio over 2.2 can be considered limestone based (Langmuir and White 1971). In Morrison Cove, a majority (>80 percent) of the stream sites and springs fall into one of these two categories. Based on Ca^{+2}/Mg^{+2} ratios, greater than 64 percent of the sites are dolomite based, 18 percent are some mixture of dolomite and limestone based water, nine percent are limestone based waters, and the remaining nine percent of sites originate in the sandstone ridges.

Eight of the 10 springs sampled were very similar in their geology based water chemistry, with Ca^{+2}/Mg^{+2} ratios between 1.05 and 1.23. This suggests that these springs are part of a dolomite based groundwater system. Plum Creek Spring 3 (S5) was the only spring that seemed to originate from limestone based geology, with a Ca^{+2}/Mg^{+2} ratio of 2.28. Additionally, two stream sites, Hickory Bottom (Y1) and the upstream site on Plum Creek (H10) also appear to be utilizing water from a similar type aquifer system as the limestone spring (S5). In general, the stream sites that were in the closest proximity to dolomite springs had Ca^{+2}/Mg^{+2} ratios that also indicated a dolomite source. However, streams that were not spring fed appeared to have a mixed dolomite and limestone source.

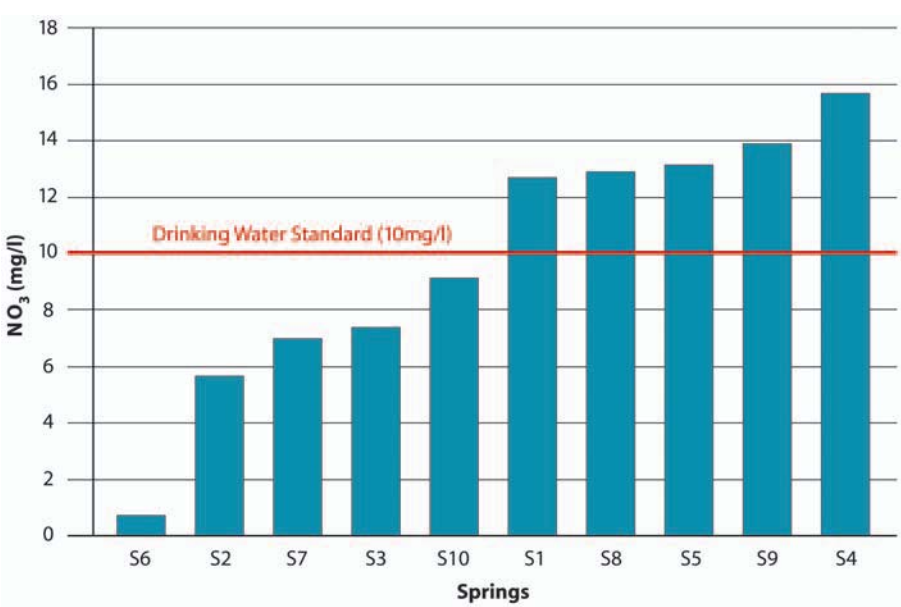

Figure 6. *Average Nitrate (NO_3) Concentrations of Sampled Springs in Morrison Cove, April 2005 - January 2006*